Australasian Transport Research Forum 2022 Proceedings
28-30 September, Adelaide, Australia
Publication website: http://www.atrf.info

Identifying MaaS schemes that maximise benefits to society through an economic appraisal framework

Sae Chi[1], Samuel Mazzer[2]

[1] Planning and Transport Research Centre (PATREC), University of Western Australia, Perth, Western Australia

[2]Hadron Group, Sydney, New South Wales

Email for correspondence: sae.chi@uwa.edu.au

Abstract

There is strong evidence of the impact Mobility-as-a-Service (MaaS) can have on individual travel behaviour. Research and trials to date have examined how the composition and incentives built into MaaS bundles can encourage behaviour that aligns with broader policies, such as increased use of public transport. The research and trials suggest that MaaS will benefit society, however, there has been limited analysis of the economic and policy implications. This paper identifies the most beneficial form of MaaS scheme using a robust economic appraisal framework. It first reviews the literature to gather evidence on the economic impacts of MaaS. It then empirically analyses the economic impacts of a hypothetical scheme in Perth, Western Australia, which are then compared with other capital city cases. This paper estimated that the net economic benefits of between $0.98 and $1.71 per vehicle removed from the Perth road network when MaaS subscribers shift to public transport, active transport and/or taxis. This paper also identified that MaaS schemes that promote a shift to public and active transport bring the greatest benefits to society, compared to the continued use of cars. The economic appraisal contributes to transport policy discussions of MaaS schemes that maximise societal benefits.

1. Introduction

Mobility-as-a-Service (MaaS) is an emerging concept where services such as public transport, taxis and micro-mobility (e.g. e-scooters) are offered as a bundle with a subscription payment. In practice, MaaS is often provided as a smartphone application whereby users can access trip planning information and purchase bundles of services or modes that meet their transport needs. Transport agencies and research organisations around the world are exploring the parameters of MaaS, including how it influences demand, mode choice and integration with the existing transport network.

Research and trials suggest that MaaS will benefit society. For example, the ability of providers to bundle transport modes can make multi-modal travel more convenient and efficient for users (Pangbourne, Mladenović, Stead, & Milakis, 2020), provides better accessibility (Eckhardt, Lauhkonen, & Aapaoja, 2020) and improves the service quality of public transport (Liljamo, Liimatainen, Pöllänen, & Viri, 2021). MaaS has also been identified to support broader social objectives such as emission reduction (Becker, Balac, Ciari, & Axhausen, 2020).

However, there has been less of a focus on quantifying the economic benefits of MaaS as it is a relatively new concept and generally not part of core transport policy. This has implications for the long-term implementation of MaaS as government agencies often draw on economic analysis to inform new transport policy positions and investment decision making.

This paper applies an economic appraisal framework (i.e. Cost-Benefit Analysis or 'CBA') to quantify the benefits of a hypothetical MaaS scheme in Perth, Western Australia, before demonstrating the results in a selection of Australian capital cities. By doing so, the paper aims to better understand the benefits of emerging MaaS technology and address identified gaps in the literature on the economic contribution to society. The analysis draws on high-level MaaS mode shift assumptions, localised historical data and national transport economic guidelines. The analysis demonstrates that MaaS schemes that encourage a shift from private vehicles to other modes of transport can deliver economic benefits to society. The analysis also highlights that an economic appraisal framework is a valuable tool to inform policy development and support the integration of Maas with the transport network.

2. Literature review

There is increasing interest in MaaS as the public and private sectors seek to optimise transport networks while addressing challenges such as road network congestion and environmental externalities. Research and trials to date have largely focused on the impact on users, such as the rate of uptake, mode choice and the Willingness to Pay (WTP) (e.g. Lopez-Carreiro et al., 2020; Matyas & Kamargianni, 2021; Zijlstra, Durand, Hoogendoorn-Lanser, & Harms, 2020) or businesses, such as commercial models, governance and implementation (e.g. Hirschhorn, Paulsson, Sørensen, & Veeneman, 2019; Karlsson et al., 2020; Surakka, Härri, Haahtela, Horila, & Michl, 2018). Within Australia, there has also been consideration of the role that governments play to support emerging transport technologies while limiting the potential for monopolies that control the MaaS platform and services (Stone et al. 2020).

Sochor et al. (2017) suggest that the impacts of MaaS can be a platform to advance societal goals. Their research identifies four levels of integration that range from siloed transport offerings which are common today to one that provides users with information, choice and convenience. The structure of a MaaS scheme and the incentives or costs associated with the transport bundles is key to promoting the desired behavioural changes that meet societal goals.

Trials within Australia have explored the parameters of MaaS and provide useful insight into the potential benefits for society. The Sydney MaaS trial examined the appetite for transport bundles, the degree of behavioural change and gather data for future initiatives (Hensher, Ho, & Reck, 2021). Although the trial had been significantly disrupted by the coronavirus pandemic, the trial has found that the financial incentives offered in the MaaS bundles can influence behaviour change and the average number of weekly private vehicle trips generally reduced after participants subscribed to the bundle (Hensher et al., 2021). Also, the trial demonstrated that users of the GreenPass, a bundle that encouraged public transport usage, had a greater reduction in private vehicle trips than other user groups (see Hensher et al., 2021).

Another trial in Brisbane, launched in mid-2021 and still currently running, offers eight bundles to staff and students of the University of Queensland, which provide unlimited public transport and a range of incentives for e-scooters, e-bikes, taxis and hire vehicles (iMOVE CRC, 2021). Through the offer, the trial aims to increase public and active transport patronage (see iMOVE CRC, 2021).

While the trials test the impact of the bundles on changes in travel behaviour, they do not explore which modes should be prioritised to support societal goals, such as reduced road transport emissions. A MaaS scheme that encourages a mode shift from private vehicle to public transport and active transport may deliver the following economic outcomes:

- Decongestion, Vehicle Operating Cost (VOC) saving, safety and reduced environmental impacts due to modal shift from driving
- Health benefits due to increased cycling and walking

- Crash costs of cycling and walking
- Environmental impacts of buses and trains.

CBA is a useful tool to quantify these economic costs and benefits of MaaS, beyond the user and business impacts, and prioritise schemes that have a net welfare impact. This paper aims to fill the gap by undertaking the CBA of MaaS schemes.

3. Economic appraisal approach

The paper quantifies the economic benefits of a hypothetical MaaS scheme that encourages a shift from private vehicles to other modes of transport. A series of high-level mode shift assumptions that reflect findings in the literature are applied to overcome limitations in the availability of localised trial data. The analysis focuses on Perth, Western Australia, with summary results provided for Brisbane, Sydney, Melbourne and Adelaide.

Step 1 involves a detailed literature review to identify research and trials that measure the changes in travel behaviour. A range of potential cost and benefits streams were identified based on conventional transport economics principles.

Step 2 focuses on developing four options that are applied in the analysis. The options aim to reflect MaaS trials that have focused on encouraging a shift away from private vehicles to other modes of transport and promote discussions about using MaaS for more sustainable transport.

Step 3 establishes overarching assumptions on the change in travel behaviour due to MaaS. Currently, there are no longitudinal MaaS trial datasets available in Australia. The first major MaaS trial in Sydney (Hensher, Ho, & Reck, 2021) was significantly disrupted by the COVID-19 outbreak in early 2020. The second MaaS trial in Brisbane is underway and is not ready to share results (iMOVE CRC, 2021). In the absence of suitable data, we assume a one per cent mode shift from private vehicles to other modes of travel across all options.

Step 4 involves collecting historic travel data which forms a basis for quantifying the economic benefits and costs associated with each option. The analysis draws on the Australian Bureau of Statistic's Journey to Work (JTW) dataset from the 2016 Census. While the COVID-19 pandemic has impacted travel behaviour since early 2020, the JTW dataset provides a useful base case to test the economic benefits of MaaS. Additional assumptions were developed to reflect typical travel behaviour (e.g. it was assumed that people travel to and from work).

Table 1 outlines the Greater Perth inputs applied in the model, based on the 2016 Census JTW datasets. Note that truck drivers, motorcyclists and people that worked from home or did not work were excluded from the analysis. Similar modelling inputs were prepared for Brisbane, Sydney, Melbourne and Adelaide.

Table 1: Greater Perth historical modelling inputs

Travel mode	Average daily travel (km)	Number of daily travellers	Modal share
Private vehicle	16	559,744	83%
Public transport (train)	23	55,379	8%
Public transport (bus)	10	29,128	4%
Public transport (ferry)	24	343	0%
Public transport (tram)	14	171	0%
Taxi	10	1,726	0%
Cycling	8	9,176	1%
Walking	4	16,343	2%
Total		**672,010**	**100%**

Step 4 also involves gathering economic parameters associated with the selected benefit and cost streams. The economic parameters and guidance for estimating the benefits and costs are detailed in the ATAP guidelines (Australian Transport and Infrastructure Council, 2016b, 2016c, 2018, 2021b). Note, the cost of implementing a MaaS scheme is not quantified in this paper and is an area for further analysis.

Step 5 focuses on modelling the scenarios to quantify the economic benefits and costs of MaaS. The modelling results inform the discussions and transport policy considerations.

3.1 Options considered

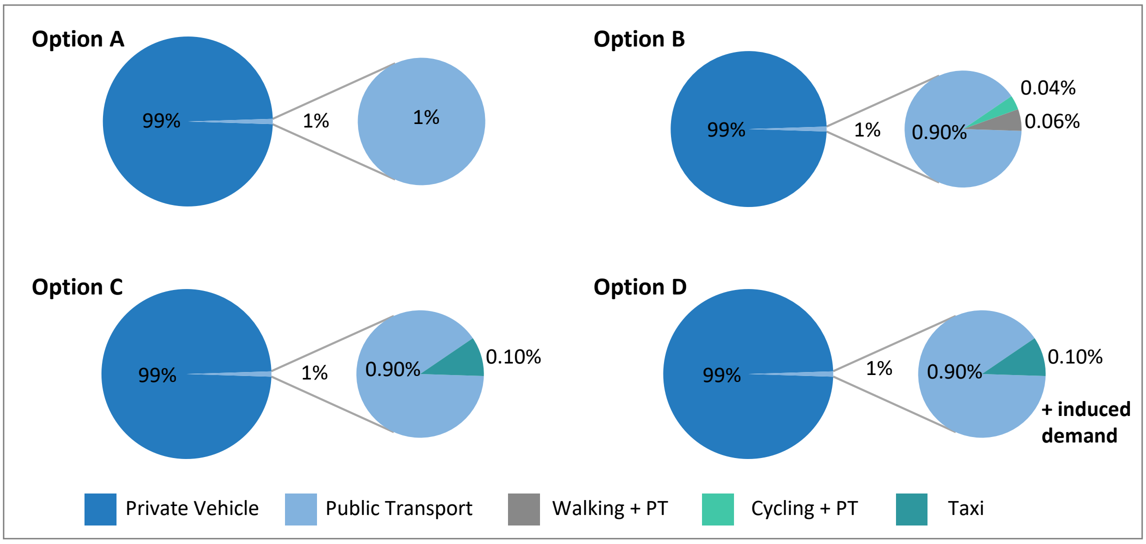
Four options were developed to test the impact of a hypothetical MaaS bundle that encouraged a shift from driving to other modes of transport. The options encouraged the following modal shift:

- **Option A:** Modal shift from private vehicle to public transport (e.g. bus and train) only
- **Option B:** Modal shift from private vehicle to public transport and active transport (e.g. walking/cycling to work or public transport station)
- **Option C:** Modal shift from private vehicles to public transport and taxis
- **Option D:** Modal shift from private vehicles to public transport, with a 10 per cent increase in induced demand for taxis.

It is important to note that this paper considers taxis rather than all ridesharing services. Rideshare services such as Uber can be included in a MaaS bundle, however, publicly available demand estimates are limited.

Figure 1 provides a graphical representation of the options assessed in the economic appraisal. Note, the modal combinations are based on the average distance travelled. Shorter journeys may be completed by active transport, rather than being combined with public transport.

Figure 1: Graphical representation of the options assessed



4. Results

An estimated 5,597 travellers shift from private vehicles to other forms of transport in Perth, including public transport (train, bus, ferry, or tram), active transport and taxis. The shift results in a slight increase in trips as some travellers use a combination of public transport and active transport to complete their journey.

Option B (shift from private vehicle to public transport and active transport) delivers the largest economic benefits, estimated at $9,584 per average weekday or $1.71 per vehicle that is no longer on the road. The economic benefits are driven by the significant reduction in road congestion, safety improvements and reduced environmental externalities. Active transport also makes an important contribution, accounting for over 35 per cent of the economic benefits.

While Option C and Option D encourage mode shift from private vehicles to public transport, the increased demand for taxis results in disbenefits on the road network. The induced demand in Option D further erodes the potential economic benefits associated with the mode shift.

Table 2 provides a breakdown of the benefits in Perth by option per average weekday.

Table 2: Economic benefits per option per ave. weekday in Perth (2021-22 dollars)

Impacts due to	Option A	Option B	Option C	Option D
Reduced demand for driving	$2,864	$2,864	$2,864	$2,864
Increased demand for taxi	$0	$0	-$286	-$286
Induced demand for taxi	$0	$0	$0	-$44
Increased demand for PT	$3,303	$3,303	$2,972	$2,972
Increased demand for cycling	$0	$1,144	$0	$0
Increased demand for walking	$0	$2,273	$0	$0
Total benefits	**$6,166**	**$9,584**	**$5,550**	**$5,506**
Total benefits per vehicle reduced	**$1.10**	**$1.71**	**$0.99**	**$0.98**

4.1 Options considered

Table 3 provides a breakdown of the economic benefits for Option B which is estimated to deliver the greatest benefits per average weekday on the Perth transport network. The reduction in private vehicle use provides the greatest economic benefit ($2,864) through reduced congestion, followed by increased public transport ($3,303) and increased walking ($2,273). While public transport delivers strong economic benefits, there are disbenefits associated with the environmental emissions of buses and trains. The higher environmental emissions of trains relative to buses reflect the significantly higher number of users that travel by rail.

Mode changer benefits make a large contribution to the overall result. The mode changer benefits include the perceived cost component of vehicle operating costs while the resource cost component has been removed as some users are no longer travelling in private vehicles.

Table 3: Economic benefits for Option B per ave. weekday (neg values are a disbenefit, 2021-22 dollars)

Benefit	Reduction in driving	Increased PT	Increased cycling	Increased walking	Total benefits
Mode changer benefits	$0	$4,429	$127	$190	**$4,746**
Decongestion impacts	$2,651	$0	$0	$0	**$2,651**
VOC adjustment	-$588	$0	$0	$0	**-$588**
Environmental impacts of cars	$182	$0	$0	$0	**$182**
Environmental impacts of buses	$0	-$229	$0	$0	**-$229**
Environmental impacts of trains	$0	-$897	$0	$0	**-$897**
Safety outcomes	$619	$0	-$981	-$555	**-$917**
Health benefits	$0	$0	$1,999	$2,638	**$4,637**
Total benefits	**$2,864**	**$3,303**	**$1,144**	**$2,273**	**$9,584**
Total benefits per vehicle reduced	**$0.51**	**$0.59**	**$0.20**	**$0.41**	**$1.71**

4.2 Comparison of Australian Capital Cities

The economic benefits of MaaS vary by capital city, reflecting differences in vehicle and public transport usage. The impact of a one per cent shift from private vehicles in cities with high transport demand results in significant economic benefits. For example, the potential benefits from the uptake of MaaS in Greater Sydney are almost $16,000 while Greater Melbourne generates benefits of over $13,000 per average weekday

Table 4: Breakdown of economic benefits by capital city for Option B per ave. weekday (2021-22 dollars)

Benefits by capital city (Option B)	Option A	Option B	Option C	Option D
Greater Perth	$6,166	$9,584	$5,550	$5,506
Greater Brisbane	$6,428	$9,174	$5,785	$5,723
Greater Sydney	$9,822	$13,043	$8,840	$8,696
Greater Melbourne	$10,871	$15,918	$9,784	$9,678
Greater Adelaide	$3,848	$5,673	$3,463	$3,430

5. Conclusions

This paper applied an economic appraisal framework to quantify the benefits of hypothetical MaaS options within Perth, Western Australia, and a selection of capital cities. The analysis addresses a gap in the literature and demonstrates that an economic appraisal framework is a useful tool to inform contemporary transport policies. The analysis also promotes a discussion about prioritising initiatives that can achieve Level 4 MaaS integration and yield the greatest benefits to society, rather than pursuing investment without a holistic assessment.

The appraisal resulted in four key findings. Firstly, MaaS bundles that incentivise increased active transport and public transport while managing the demand for services that carry high economic costs, such as private vehicles and taxis, will maximise the economic benefits to society. Public and active transport deliver strong economic benefits through increased health outcomes, reduced environmental externalities and high patronage relative to the number of vehicles/carriages on the transport network.

Secondly, the appraisal outcome inherently reflected the aim of the MaaS scheme. Therefore, the societal objectives that inform the policy decisions and advocacy must directly feed into the structure and incentives of the MaaS bundles.

Third, without strong demand for active transport and public transport, the economic benefits of MaaS to society are likely to be limited. Further analysis is needed to determine if subsidising MaaS aligns with government policy and delivers the desired benefits or whether the private sector should be encouraged to identify a sustainable model.

Lastly, this paper provided a simplified economic view of MaaS and did not consider the wider impacts on the network. Further work is needed to quantify impacts, such as increased public transport crowding and safety implications due to modal shift, financial implications (e.g. farebox revenues) and asset management responses.

6. References

Australian Transport and Infrastructure Council. (2016b). *Australian Transport Assessment and Planning Guidelines: M5 Travel Behaviour Change*. Retrieved from https://atap.gov.au/mode-specific-guidance/travel-behaviour-change/index.aspx

Australian Transport and Infrastructure Council. (2016c). *Australian Transport Assessment and Planning Guidelines: PV2 Road Parameter Values*. Retrieved from https://atap.gov.au/parameter-values/index.aspx

Australian Transport and Infrastructure Council. (2018). *Australian Transport Assessment and Planning Guidelines: T2 Cost Benefit Analysis*. Retrieved from https://atap.gov.au/tools-techniques/cost-benefit-analysis/index.aspx

Australian Transport and Infrastructure Council. (2021b). *Australian Transport Assessment and Planning Guidelines: PV5 Environmental*. Retrieved from https://www.atap.gov.au/parameter-values/environment/index

Becker, H., Balac, M., Ciari, F., & Axhausen, K. W. (2020). Assessing the welfare impacts of Shared Mobility and Mobility as a Service (MaaS). *Transportation Research Part A: Policy and Practice*, *131*, 228–243. https://doi.org/10.1016/j.tra.2019.09.027

Climate Change Authority (Australian Government). 2021. *Transport.* Retrieved from: https://www.climatechangeauthority.gov.au/sites/default/files/2021-03/2021Fact%20sheet%20-%20Transport.pdf

Eckhardt, J., Lauhkonen, A., & Aapaoja, A. (2020). Impact assessment of rural PPP MaaS pilots. *European Transport Research Review*, *12*(1), 49. https://doi.org/10.1186/s12544-020-00443-5

Hensher, D. A., Ho, C. Q., & Reck, D. J. (2021). Mobility as a service and private car use: Evidence from the Sydney MaaS trial. *Transportation Research Part A: Policy and Practice*, *145*, 17–33. https://doi.org/10.1016/j.tra.2020.12.015

Hirschhorn, F., Paulsson, A., Sørensen, C. H., & Veeneman, W. (2019). Public transport regimes and mobility as a service: Governance approaches in Amsterdam, Birmingham, and Helsinki. *Transportation Research Part A: Policy and Practice*, *130*(September), 178–191. https://doi.org/10.1016/j.tra.2019.09.016

iMOVE CRC. (2021). ODIN PASS: A Mobility as Service trial at UQ. Retrieved December 15, 2021, from https://imoveaustralia.com/project/odin-pass-a-mobility-as-service-trial-at-uq/

Karlsson, I. C. M., Mukhtar-Landgren, D., Smith, G., Koglin, T., Kronsell, A., Lund, E., … Sochor, J. (2020). Development and implementation of Mobility-as-a-Service – A qualitative study of barriers and enabling factors. *Transportation Research Part A: Policy and Practice*, *131*(September 2019), 283–295. https://doi.org/10.1016/j.tra.2019.09.028

Liljamo, T., Liimatainen, H., Pöllänen, M., & Viri, R. (2021). The Effects of Mobility as a Service and Autonomous Vehicles on People's Willingness to Own a Car in the Future. *Sustainability*, *13*(4), 1962. https://doi.org/10.3390/su13041962

Lopez-Carreiro, I., Monzon, A., Lopez, E., & Lopez-Lambas, M. E. (2020). Urban mobility in the digital era: An exploration of travellers' expectations of MaaS mobile-technologies. *Technology in Society*, *63*, 101392. https://doi.org/10.1016/j.techsoc.2020.101392

Matyas, M., & Kamargianni, M. (2021). Investigating heterogeneity in preferences for Mobility-as-a-Service plans through a latent class choice model. *Travel Behaviour and Society*, *23*, 143–156. https://doi.org/10.1016/j.tbs.2020.12.002

Pangbourne, K., Mladenović, M. N., Stead, D., & Milakis, D. (2020). Questioning mobility as a service: Unanticipated implications for society and governance. *Transportation Research Part A: Policy and Practice*, *131*, 35–49. https://doi.org/10.1016/j.tra.2019.09.033

Sochor, J., Karlsson, I. C. M., & Strömberg, H. (2016). Trying Out Mobility as a Service: Experiences from a Field Trial and Implications for Understanding Demand. *Transportation Research Record: Journal of the Transportation Research Board*, *2542*(1), 57–64. https://doi.org/10.3141/2542-07

Sochor, J., Arby, H., Karlsson, I.C.M, & Sarasini, S. (2017). A topological approach to Mobility as a Service: A proposed tool for understanding requirements and effects, and for aiding the integration of societal goals. *Research in Transportation Business and Management, 27*, 3-14. https://doi.org/10.1016/j.rtbm.2018.12.003.

Stone, J., Ashmore, D., Legacy, C. & Curtis, C. (2020). Challenges for Government as Facilitator and Umpire of Innovation in Urban Transport: The View from Australia. *Shaping Smart Mobility Futures: Governance and Policy Instruments in times of Sustainability Transitions.* Emerald Publishing Limited, 105-118. https://doi.org/10.1108/978-1-83982-650-420201006

Surakka, T., Härri, F., Haahtela, T., Horila, A., & Michl, T. (2018). Regulation and governance supporting systemic MaaS innovations. *Research in Transportation Business and Management*, *27*, 56–66. https://doi.org/10.1016/j.rtbm.2018.12.001

Zijlstra, T., Durand, A., Hoogendoorn-Lanser, S., & Harms, L. (2020). Early adopters of Mobility-as-a-Service in the Netherlands. *Transport Policy*, *97*, 197–209. https://doi.org/10.1016/j.tranpol.2020.07.019